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Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS) Operations Concept

Revision 1

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National Aeronautics and Space Administration

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Greenbelt, Maryland

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Preface

The Level 1 Product Generation System (LPGS), in conjunction with the Earth Science Earth Observing System (EOS) Ground System (EGS), will provide both radiometrically and geometrically corrected (Level 1R and Level 1G) products to the Landsat 7 program.

Revision 1 to this Operations Concept is the result of Configuration Change Request (CCR) LPGS970014. This reflects all changes to the LPGS operations philosophy since the December 1996 System Requirements Review (SRR)/System Design Review (SDR).

This document is maintained and controlled by the LPGS Project Configuration Management Board (PCMB) and can be updated or revised only on approval by the PCMB. Comments and questions regarding this document should be directed to

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Abstract

The Level 1 Product Generation System (LPGS) operations concept describes how the LPGS will be operated within the Earth Observing System (EOS) Ground System (EGS) to provide Land Satellite 7 (Landsat 7) Enhanced Thematic Mapper Plus (ETM+) systematically corrected digital images to EOS Data and Information System (EOSDIS) Core System (ECS) customers. The LPGS operations concept also provides a topology for the LPGS architecture and describes the interfaces to external elements. The concepts are derived from the Earth Science Data and Information System (ESDIS) Project Mission-Specific Requirements for the Landsat 7 Mission Level 1 Processing system document, and they are consistent with the ECS to Landsat 7 System interface control document (ICD).

Keywords: *Distributed Active Archive Center (DAAC), Earth Observing System Data and Information System (EOSDIS), EOSDIS Core System (ECS), Earth Resources Observation System (EROS) Data Center (EDC), Landsat 7, Level 1 product, Level 1 Product Generation System (LPGS)*

Change Information Page

List of Effective Pages	
Page Number	**Issue**
Title page	Revision 1
iii through xi	Revision 1
1-1 through 1-7	Revision 1
2-1 through 2-7	Revision 1
3-1 through 3-6	Revision 1
AB-1 through AB-2	Revision 1

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Contents

Preface

Abstract

Section 1. Introduction

1.1 Operations Concept Scope 1-1

1.2 Applicable Documents 1-1

1.3 Definitions 1-2

1.4 LPGS Environment 1-4

1.4.1 Landsat 7 Image Collection and Production End-to-End Data Flow 1-4

1.5 LPGS Goals and Objectives 1-7

Section 2. LPGS Overview

2.1 LPGS Description 2-1

2.2 External Interfaces 2-2

2.2.1 Interface to ECS 2-2

2.2.2 Interface to IAS 2-2

2.3 Functional and Operational Capabilities 2-3

2.3.1 Receive and Process L1 Product Generation Requests 2-3

2.3.2 Plan L1 Data Production 2-3

2.3.3 Request and Receive L0R Products 2-3

2.3.4 Generate Radiometrically and Geometrically Corrected Digital Images 2-3

2.3.4.1 Generate L1R Images 2-3

2.3.4.2 Generate L1G Images 2-3
2.3.4.3 Collect Performance and Data Quality Information 2-3
2.3.4.4 Collect Radiometric Characterization Information 2-4
2.3.4.5 Reprocess Requests 2-4
2.3.5 Distribute L1 Product 2-4
2.3.6 Recover Disk Space 2-4
2.4 LPGS Reference Architecture 2-5
2.4.1 Functional Areas 2-5
2.4.2 Reference Topology 2-6
2.5 LPGS System Support 2-7
2.6 Security 2-7

Section 3. LPGS Operations

3.1 Performance Requirements 3-1
3.2 Nominal Operations 3-1
3.2.1 L1 Typical Daily Activity 3-2
3.2.1.1 Preproduction 3-2
3.2.1.2 Production 3-2
3.2.1.3 Postproduction 3-3
3.2.2 Data Quality Analysis and Anomaly Resolution 3-3
3.2.2.1 Anomalies Found During L1 Processing and Postproduction Analysis 3-3
3.2.2.2 Response to Customer Report of Anomalies 3-4
3.2.3 Algorithm Update 3-4
3.2.4 Reprocessing 3-4

3.2.5 Product Accounting 3-5
3.2.6 Documentation and Production Software Distribution 3-5
3.2.7 System Test and Maintenance 3-5
3.3 Contingency Operations 3-5
3.3.1 LPGS Failure 3-5
3.3.2 Failure of Communication Links to the ECS 3-6

Abbreviations and Acronyms

Figures

1-1 EGS Overview 1-5
1-2 Landsat 7 Data Flow 1-6
2-1 LPGS Context 2-1
2-2 LPGS Architecture 2-6

Tables

2-1 LPGS External Interfaces 2-2
2-2 L1 Product Contents 2-4
3-1 LPGS Input Requirements 3-1
3-2 LPGS Production and Distribution Requirements 3-1

Section 1. Introduction

1.1 Operations Concept Scope

The operations concept describes how the Level 1 (L1) Product Generation System (LPGS) will be operated within the Earth Observing System (EOS) Ground System (EGS) and will interface with systems supporting the Land Satellite 7 (Landsat 7) System and other EGS elements. The LPGS produces radiometrically and systematic geometrically corrected digital images of data collected by the Landsat 7 Enhanced Thematic Mapper Plus (ETM+). The concepts presented are responsive to the Earth Science Data and Information System (ESDIS) Level 2 requirements documented in the ESDIS Project Mission-Specific Requirements for the Landsat 7 Mission Level 1 Processing (Applicable Document 9).

1.2 Applicable Documents

Information from the following documents was used in developing the LPGS operations concepts:

1. EOSDIS Core System (ECS) Project, 223-CD-001-002, *ECS External Data Traffic Requirements*, August 1996
2. —, 604-CD-002-003, *ECS Operations Concept for the ECS Project: Part 2B - ECS Release B*, March 1996
3. Hughes Information Technology Systems, 505-41-32, *Interface Control Document (ICD) Between EOSDIS Core System (ECS) and the Landsat 7 System, Revision A*, May 1997
4. ECS, 305-CD-027-002, *Release B SDPS Data Processing Subsystem Design Specification*, March 1996
5. —, 604-CD-003-002, *ECS Operations Concept for the ECS Project: Part 2A - ECS Release A*, November 1995
6. —, 305-CD-029-002, *Release B CSMS System Management Subsystem Design Specification for the ECS Project*, July 1994
7. —, 194-207-SE1-001, *System Design Specification for the ECS Project*, June 1994
8. —, 305-CD-024-002, *Release B SDPS Data Server Subsystem Design Specification for the ECS Project*
9. National Aeronautics and Space Administration (NASA), Goddard Space Flight Center (GSFC), *Earth Science Data and Information System (ESDIS) Project Mission-Specific Requirements for the Landsat 7 Mission Level 1 Processing*, July 1997
10. —, *Landsat 7 Level 1 Product Generation System (LPGS) Project Management Plan*, Draft, May 1996

11. —, 514-1ICD/0195, *ICD Between IAS and LPS*, January 31, 1996

12. —, 560-3OCD/0194, *Landsat 7 Processing System (LPS) Operations Concept, Revision 2,* April 15, 1996

13. —, 505-41-18, *IRD Between EOSDIS and MITI ASTER GDS Project*, July 1995

14. —, 505-41-13, *IRD Between EOSDIS and the Landsat-7 System*, July 1995

15. —, *Landsat 7 Detailed Mission Requirements*, May 1995

16. —, *IAS Operations Concept*, December 19, 1994

17. —, 430-15-01-001-0, *Landsat 7 System IAS Element Specification, Baseline,* September 17, 1996

18. —, NHB 2410.9A, *NASA Automated Information Security Handbook*, June 1993

19. —, 505-10-23, *ESDIS Security Policy and Guidelines*, March 1996

20. —, *Landsat 7 Level 1 Product Generation System and Image Assessment System Software Configuration Management Plan*, October 1997

21. —, 423-41-55, *Interface Control Document (ICD) Between the Earth Observing System Data and Information System (EOSDIS) Core System (ECS) and the Level 1 Product Generation System (LPGS)*, October 1997

22. —, 514-4ICD/0197, *Interface Control Document (ICD) Between the Landsat 7 Image Assessment System (IAS) and the ESDIS Level 1 Product Generation System (LPGS)*, February 1998

1.3 Definitions

The following terms, as defined in this section, are commonly used throughout this document to describe the LPGS operations concept:

- Level 0R (L0R) digital image—Spatially reformatted, demultiplexed, and unrectified subinterval data
- Level 0R (L0R) product—L0R digital image plus radiometric, calibration, attitude, and ephemeris data, consisting of the following files in hierarchical data format (HDF):
  - L0R digital image
  - Internal calibrator (IC) data—Calibration data file containing all the calibration data received on a major frame basis for a given subinterval
  - Mirror scan correction data (MSCD)—Scan direction and error information for a given subinterval
  - Payload correction data (PCD)—Information on spacecraft attitude and ephemeris, including quality indicators for each subinterval

  - Metadata—Descriptive information about the L0R image and names of appended files associated with the image.
  - Calibration parameter file (CPF)—A formatted file containing gains, biases, and offsets for the instrument and detectors.
  - Scan line offsets—Information on actual starting and ending pixel positions for valid image data on a line-by-line basis.
  - Geolocation index—A file containing scene corner coordinates and product-specific scene line numbers for bands.
  - HDF directory—A file containing all the pointers, file size information, and data objects required to process the L0R product.

- Level 1R (L1R) digital image—Radiometrically corrected but not geometrically resampled. Image size can be from 0.5 to 3 Worldwide Reference System (WRS) scene equivalents. Can be WRS-based or have a floating scene center but is restricted to one orbital path and must be generated from the same Level 0 acquisition interval.
- Level 1G (L1G) digital image—Radiometrically corrected and resampled for geometric correction and registration to geographic map projections. Image size can be from 0.5 to 3 WRS scene equivalents. Can be WRS-based or have a floating scene center but is restricted to one orbital path and must be generated from the same Level 0 acquisition interval.
- Level 1R (L1R) product—L1 product packaged by LPGS and distributed by the ECS to the customer. Includes, for all requested bands, L1R digital image, Landsat Processing System (LPS) metadata, LPGS metadata, IC data files, CPF, consensus PCD file, consensus MSCD file, geolocation table, and scan line offsets in HDF.
- Level 1G (L1G) product—L1 product packaged by LPGS and distributed by the ECS to the customer. Includes, for all requested bands, FAST format or Georeferenced Tagged Image File Format (GeoTIFF) L1G image and associated data accommodated by the format; or HDF L1G image and LPGS metadata.
- Interval—Time duration between the start and stop of an imaging operation (observation) of the Landsat 7 ETM+ instrument
- Subinterval—Segment of time corresponding to a portion of an observation within a single Landsat 7 contact period
- Worldwide Reference System (WRS) scene—Digital image that covers an area equivalent to one of the 57,784 scene-centers (233 paths x 248 rows areas) defined by the WRS structure

1.4 LPGS Environment

The LPGS is a source of ETM+ L1 data within the EGS, shown in the EGS overview (Figure 1-1). The EGS is a collection of ground support elements for EOS and includes the EOS Data and Information System (EOSDIS), institutional support elements, affiliated and international partner data centers, international partner instrument control and operations centers, and other sources of data. The LPGS is located at the Earth Resources Observation System (EROS) Data Center (EDC) Distributed Active Archive Center (DAAC) and provides ETM+ L1 product generation and distribution services on a demand basis. The LPGS receives L1 product generation requests and distributes generated products to customers through the EOSDIS Core System (ECS) at the EDC DAAC on a first in, first out (FIFO) basis. The LPGS is the responsibility of the ESDIS Project and will be developed at the Goddard Space Flight Center (GSFC) and installed at the EDC DAAC to provide product generation and distribution support for a Landsat 7 minimum mission life of 5 years.

1.4.1 Landsat 7 Image Collection and Production End-to-End Data Flow

Figure 1-2 shows the flow of data from the Landsat 7 platform and ETM+ instrument to customers. The Mission Operations Center (MOC) plans and schedules ETM+ data collection and downlink based on mission objectives of refreshing the global archive, weather and orbit information, spacecraft constraints, and acquisition requests received from international ground stations (IGSs). IGSs' requests routinely include data collection for all land mass coverage within the station's field of view. The MOC transmits spacecraft commands to the Landsat ground network (LGN) for uplink to the Landsat 7 platform and the ETM+ instrument. The ETM+ instrument collects images over land masses and either records image data on an onboard solid state recorder (SSR) for downlink when in sight of a ground station, or downlinks data in real time to the Landsat 7 ground station (LGS) or IGS. The LGS can simultaneously receive SSR and real-time data downlink. The LGS transmits raw data to the LPS, which produces reformatted Level 0 (L0R) data and browse and inventory metadata that are transmitted to the EDC DAAC for archive. IGSs produce higher level products from the downlinked, wideband data and periodically transmit browse and inventory metadata to the EDC DAAC for archive. Customers access the ECS search and order facilities and query the availability of ETM+ products. L0R and IGS product metadata and browse images can be accessed and viewed to identify desired products. Customers submit requests for IGS products directly to the IGSs, which are responsible for distributing their products directly to the customer. Customers submit orders for standard L0R products and requests for generation of L1 products through the ECS interface. Requested L0R data are extracted from the EDC DAAC and directly distributed to the customer in response to the customer's product request. The ECS component at the EDC DAAC submits L1 product generation requests to the LPGS in response to customer requests for L1 products. The LPGS creates L1 digital images and associated files and distributes them to the ECS in response to the product generation request. The ECS in turn distributes the requested L1 products to the customer.

Figure 1-1. EGS Overview

Figure 1-2. Landsat 7 Data Flow

1.5 LPGS Goals and Objectives

LPGS concepts have been developed in accordance with project goals of maintaining system and operations cost and development schedule objectives and of reducing risks. LPGS concepts will accommodate an additional goal of employing common algorithms for initial Image Assessment System (IAS) and LPGS releases. Concepts that include allocation of requirements to existing or concurrently developed systems have been analyzed and have been adopted based on tradeoff analyses.

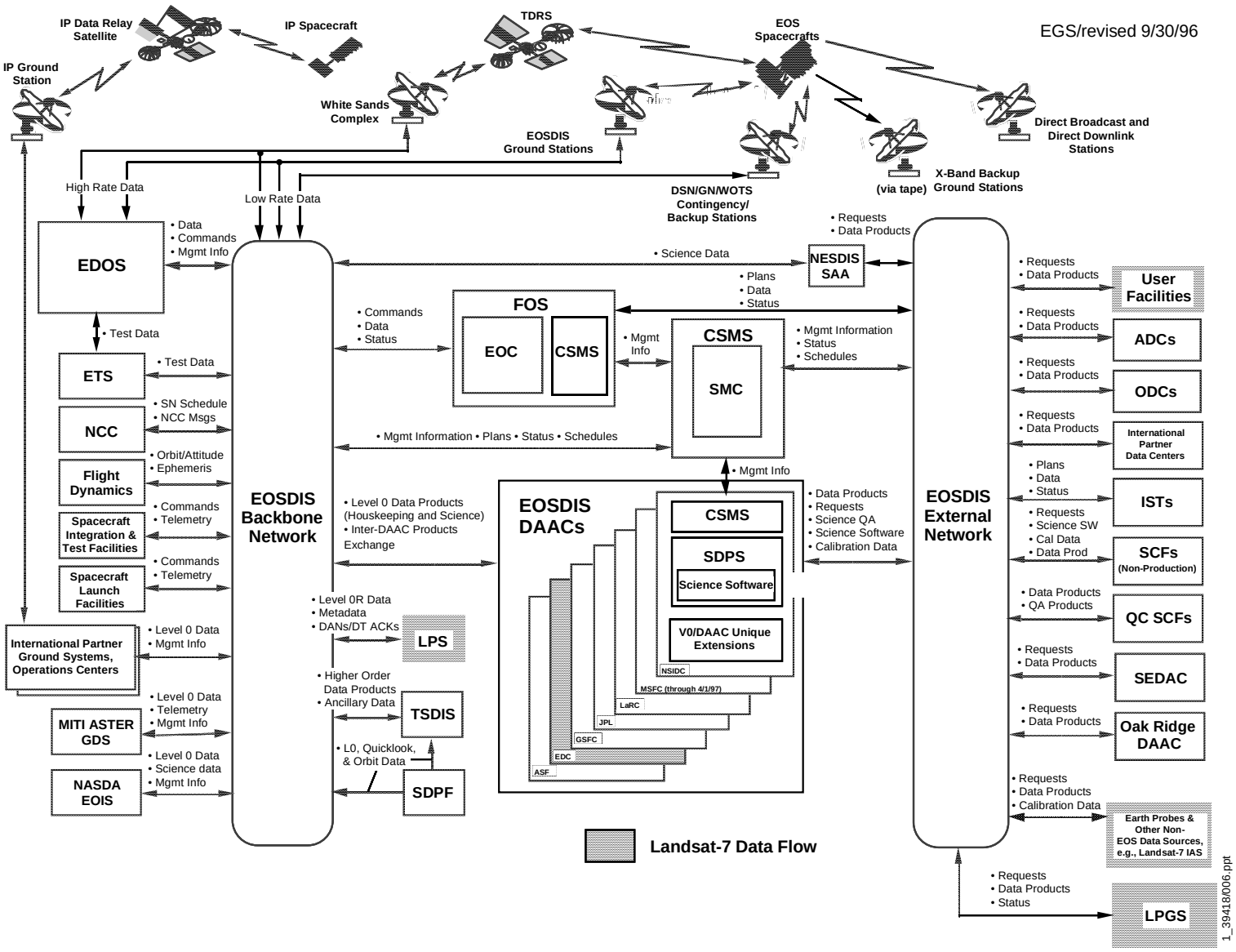

Figure 1-1. EGS Overview

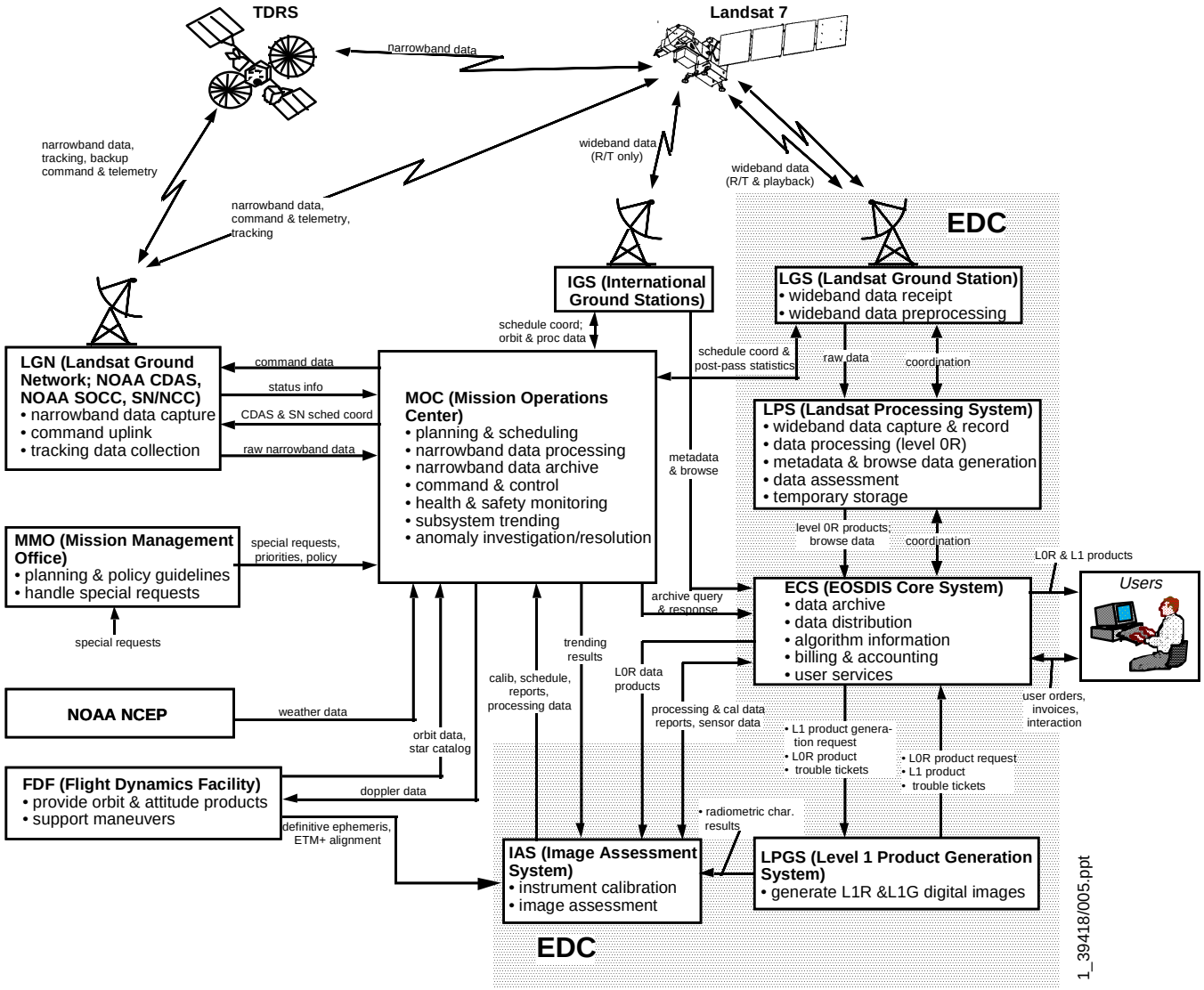

Figure 1-2. Landsat 7 Data Flow

Section 2. LPGS Overview

The LPGS is the EGS element that produces both radiometrically and systematic geometrically corrected digital images from data collected by the Landsat 7 ETM+ instrument. Key aspects of the operations and interfaces of LPGS, shown in Figure 2-1, are presented in the sections below.

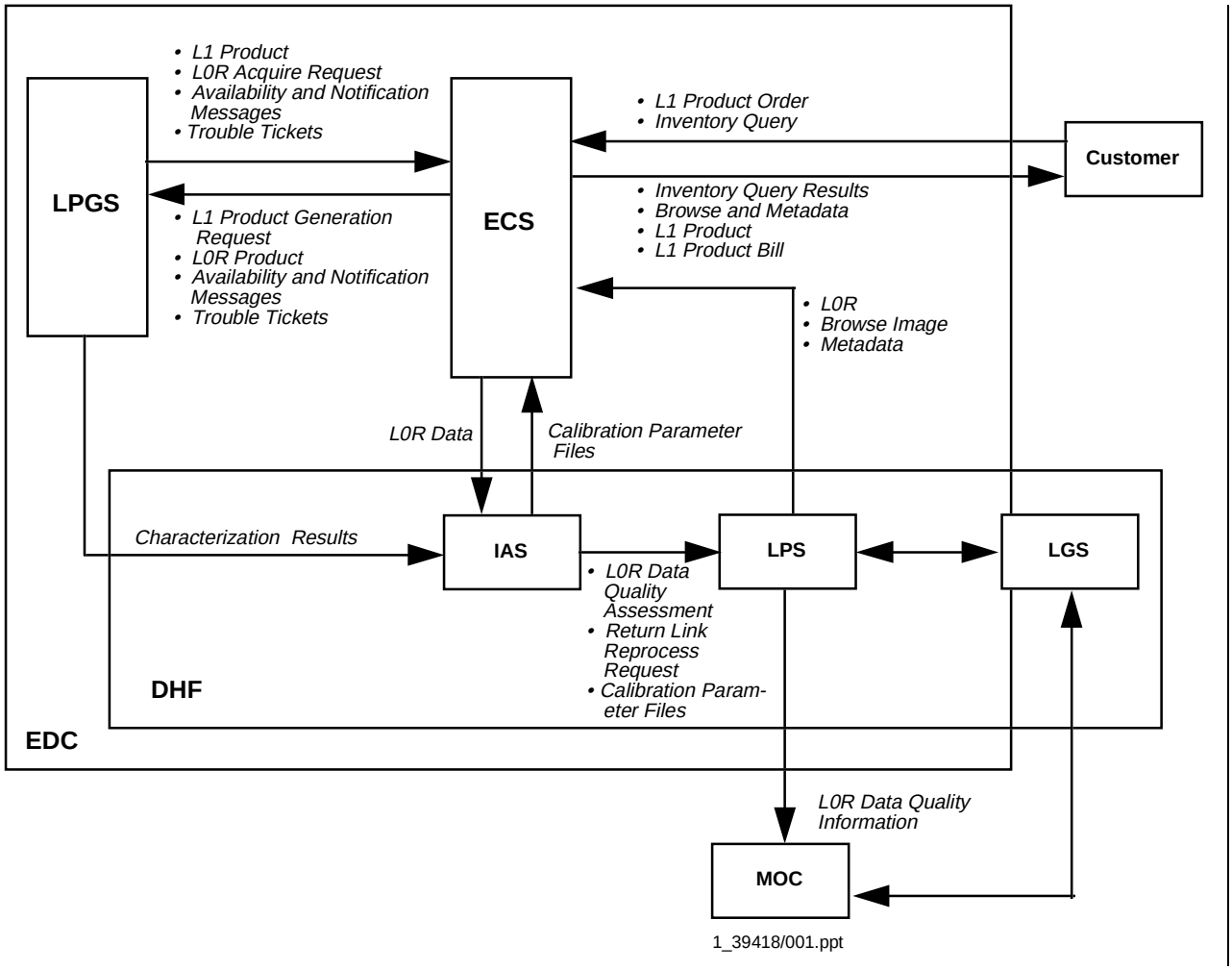

Figure 2-1. LPGS Context

2.1 LPGS Description

The LPGS produces L1 products in electronic format corresponding to a WRS scene or partial ETM+ subinterval, of from 0.5 to 3 WRS scene equivalents, based on customer requests. The LPGS is capable of producing a daily volume of 25 WRS scene equivalents of L1G, radiometrically corrected and digitally resampled for geometric correction and geographic

registration. LPGS can create digital images projected to different coordinate reference systems, for any subset of the eight spectral channels collected by the ETM+ instrument, or in different output formats according to options specified in the customer's requests. L0R data are requested from the ECS, and appended CPFs and PCD and MSCD files are applied by the LPGS in producing L1 products.

The L1 product is provided to the ECS. The ECS distributes the entire L1 product (including L1 digital image, CPF data, PCD, MSCD, scan line offsets, IC data, and metadata) to the customer.

2.2 External Interfaces

The LPGS interfaces with the ECS and the IAS are described below. Table 2-1 provides a summary of inputs and outputs.

Table 2-1. LPGS External Interfaces

Element Interface	Inputs to LPGS	Outputs From LPGS
ECS	• L1 product generation request • L0R product • Trouble tickets • Availability and notification messages	• L0R acquire request • L1 product • Trouble tickets • Availability and notification messages
IAS		• Characterization results

2.2.1 Interface to ECS

The primary LPGS interface is with the ECS within the EDC DAAC. The LPGS retrieves L1 product generation requests [also known as user request files (URFs)] from the ECS. The LPGS begin processing an L1 product generation request by submitting an L0R acquire request to the ECS. The LPGS then electronically retrieves L0R products, including a CPF, in response to the request. During L1 product generation, the LPGS generates production status information. After completion of L1 processing, the images and other pieces of the L1 product are electronically provided to the ECS. The LPGS also interfaces with the ECS to receive and submit trouble tickets. The ECS sends trouble tickets to the LPGS when problems are reported after the L1 products have been transferred to the ECS. The LPGS submits trouble tickets to the ECS for anomalies discovered during L1 production that cannot be resolved by the LPGS anomaly analysts.

2.2.2 Interface to IAS

During L1 image processing, various characterizations are performed. The LPGS collects results of radiometric characterizations and periodically makes them available to the IAS for retrieval and use in trending and further analysis.

2.3 Functional and Operational Capabilities

This section describes the high-level functions performed by the LPGS.

2.3.1 Receive and Process L1 Product Generation Requests

The LPGS receives URFs, which are customer orders for L1 products, from the ECS Planning Subsystem (PLS). The L1 URFs are processed by the LPGS to extract customer parameters and options, extract the identifiers for L0R products that will be processed, and generate a product request.

2.3.2 Plan L1 Data Production

The LPGS adds L1 product requests into the L1 processing queue. Processing resources are allocated for the requested L1 data production on a FIFO basis, although product requests can be promoted in the processing queue. The LPGS provides the operator with the capability to manually promote product requests within the processing queue. This capability allows operators to control the production queue to accommodate work shift staffing modifications and reduce impacts on the production flow of product requests that require more intensive processing.

2.3.3 Request and Receive L0R Products

The LPGS creates an acquire request for an L0R product based on the status of the L1 processing queue. The LPGS transmits the L0R acquire request to the ECS. In response, the ECS stages the L0R product, including the appended files, on ECS disk space and notifies the LPGS that the product is available for the LPGS to retrieve.

2.3.4 Generate Radiometrically and Geometrically Corrected Digital Images

2.3.4.1 Generate L1R Images

The LPGS generates radiometrically corrected digital images by applying the customer-specified parameters.

2.3.4.2 Generate L1G Images

According to customer-specified parameters, the LPGS resamples L1R data for geometric correction and geographic registration to map projections.

2.3.4.3 Collect Performance and Data Quality Information

Based on configured options and thresholds, the LPGS performs and stores results from quality checks when processing and formatting digital images. Based on specified options, visual inspection of products can be performed after L1R processing, L1G processing, and/or final product formatting. Nominally, L1 products are generated without operator intervention. The LPGS generates information that provides an assessment of data quality and accuracy of a produced image, and an indicator of production processor performance for specified time periods

or product requests. Data and performance assessment reports can be generated from the information and accessed by operators for real-time analysis during production runs.

2.3.4.4 Collect Radiometric Characterization Information

Characterization data, from characterizations performed during image processing, are periodically retrieved by the IAS. After the IAS has retrieved them, the data are marked for deletion and periodically purged from the LPGS database.

2.3.4.5 Reprocess Requests

An L1 product can be reprocessed because of an unacceptable quality assessment of an L1 image before distribution of the product to the ECS. A small portion of the available resources is reserved to accommodate these types of reprocessing runs. Data reprocessing runs, in response to trouble tickets and product anomalies detected by the customer, are added to the LPGS production queue and may be promoted in the processing queue, if necessary.

2.3.5 Distribute L1 Product

The LPGS provides L1 products to the ECS for retrieval and final distribution to customers. Table 2-2 details the L1 product components. The LPGS notifies the ECS that products are available for retrieval.

Table 2-2. L1 Product Contents

Component	HDF		FAST-L7	GeoTIFF
	L1R	L1G		
L1 digital image	X*	X*	X*	X**
Header file			X	
CPF	X			
PCD	X			
MSCD	X			
Metadata (LPS)	X			
IC data	X			
Metadata (LPGS)	X	X		
Scan line offsets	X			
Geolocation table	X			

*For each requested band.
**Format embeds metadata in file that contains image.

2.3.6 Recover Disk Space

L0R and L1 products are purged from LPGS disk space after processing is completed and the ECS has pulled the L1 product and notified the LPGS that the product is valid. The recovery of

disk space is performed automatically at operator-specified intervals. Optionally, the operator can manually invoke the process of purging the disks.

2.4 LPGS Reference Architecture

Trade-off analyses resulted in the selection of an LPGS reference architecture in which the LPGS is a system within the EGS that is external to the ECS.

2.4.1 Functional Areas

This topology is based on partitioning the LPGS into several functional areas. A description of each area and a list of the high-level functions it performs are provided below.

- Data management
  - L0R product ingest
  - Formatting and packaging of L1 product
  - Distribution of L1 product
  - Communication with external interfaces
  - Resource management
- Process control
  - Production processing scheduling
  - Set up, monitoring, and control of production processing
- Image processing
  - L1R image generation
  - L1G image generation
  - Characterization statistics generation
  - Reprocessing
- Anomaly analysis
  - Anomaly resolution analysis
  - Trouble ticket submission and resolution
  - Benchmark/diagnostic runs
- Quality assessment
  - Automatic quality assessment
  - Visual quality assessment

- Development, test, and maintenance
  - System development
  - System integration and test
  - Training support

2.4.2 Reference Topology

Figure 2-2 depicts an architecture in which the LPGS is a standalone system independent of the ECS. The LPGS data management function maintains interfaces with the ECS data server subsystem (DSS) via a gateway (GW) for the exchange of protocol messages related to the L0R product and for retrieving the L0R product. The data management function also maintains interfaces with the ECS planning subsystem (PLS) and the ingest subsystem (INS) for the retrieval of URFs and for the exchange of protocol messages related to the L1 product, respectively. The ECS INS interfaces with the LPGS data management function to retrieve the L1 product. The LPGS anomaly analysis function maintains an interface with the ECS for the exchange of trouble tickets.

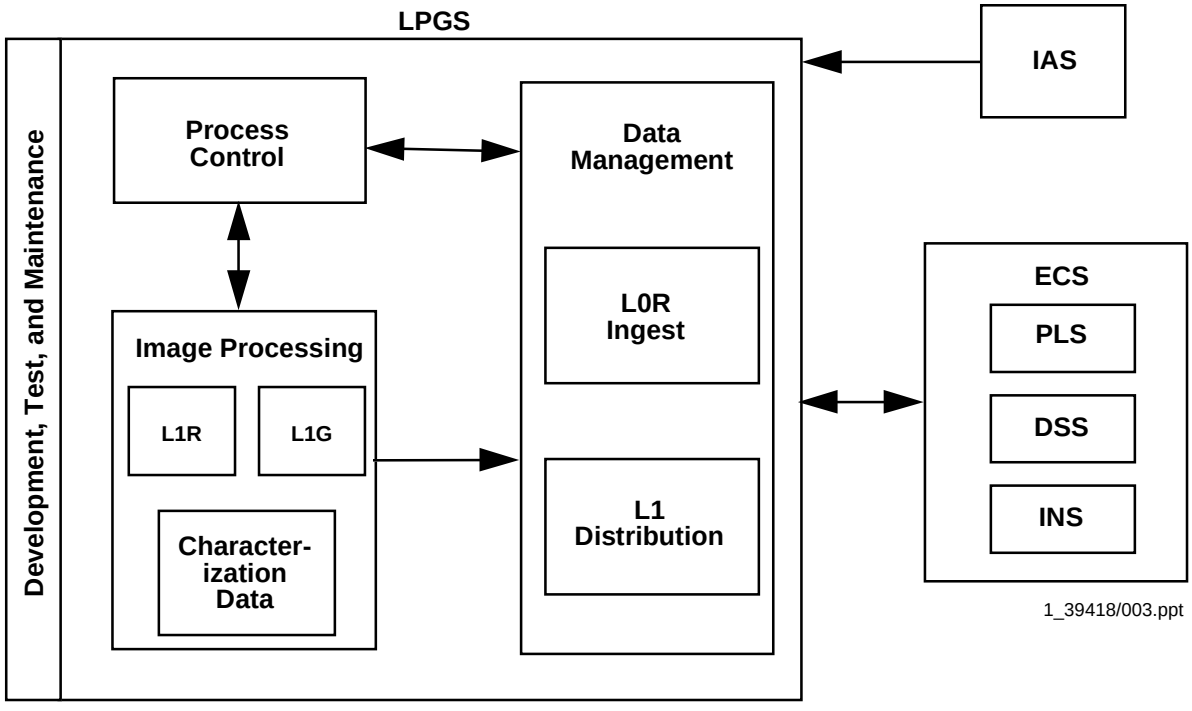

Figure 2-2. LPGS Architecture

2.5 LPGS System Support

This section documents peripheral or supporting requirements, including training and maintenance needs, that affect system design. Updates to the radiometric and geometric correction algorithms are provided to the LPGS development, test, and maintenance functions for testing and baseline integration. Updated algorithms are integrated into the image processing software in accordance with configuration control guidelines and project maintenance and sustaining engineering operations procedures. Procedures will be developed to avoid lengthy configuration change request (CCR) approval and documentation cycles, when needed, to allow expedited modification to operational algorithms to limit impacts on the production schedule and image quality.

2.6 Security

The LPGS architecture and operations will comply with security requirements and procedures established in the *NASA Automated Information Security Handbook* (Applicable Document 18) and the *ESDIS Security Policy and Guidelines* (Applicable Document 19).

Section 3. LPGS Operations

LPGS operations have been allocated to three different phases of activities: preproduction, production, and postproduction. The preproduction phase includes production planning, scheduled system maintenance, algorithm integration, and product request processing in preparation for L1 production. The production phase includes the actual processing of L0R products to create systematically corrected digital images. This phase includes generation of real-time data and production quality assessments that can be visually inspected or automatically monitored during various stages of product generation. The postproduction phase includes generating the L1 product, marking characterization data for IAS retrieval, and flagging files for deletion. All phases include both automatic and manually performed activities.

3.1 Performance Requirements

Tables 3-1 and 3-2 summarize LPGS input, production, and distribution requirements derived from the L2 requirements, and the IRD between EOSDIS and the Landsat 7 System (Applicable Document 14). Data volumes are derived from image volumes contained in the IAS Element Specification (Applicable Document 17).

Table 3-1. LPGS Input Requirements

Data	Interface	Volume
L0R product	ECS	13 GB/day
L1 URF	ECS	<100 MB/day
Trouble tickets	ECS	<100 MB/day

Table 3-2. LPGS Production and Distribution Requirements

Data	Interface	Output Volume
L0R acquire request	ECS	<100 MB/day
L1 product	ECS	31 GB/day
Characterization results	IAS	3.2 MB/day
Trouble ticket	ECS	<100 MB/day

3.2 Nominal Operations

This section describes major operational activities performed by the LPGS in nominal mode.

3.2.1 L1 Typical Daily Activity

The subsections that follow provide a narrative of operations activities that may be performed for processing a product request on a typical day.

3.2.1.1 Preproduction

On a typical day, operators review the current status of the processing queue for that day. L1 processing is performed on a FIFO basis, with the operators able to promote product requests in the processing queue, as needed.

Numerous times each day, at a time interval designated and entered into the system by the operator, the LPGS automatically assesses system storage capacity. The LPGS maintains a minimum available storage volume for L0R products waiting for processing and L1 products waiting for retrieval. When the available LPGS temporary storage approaches the minimum, the LPGS purges L0R products that have expired or L1 products that have been successfully retrieved by the ECS. L0R products have expired when the product request from which they were processed has been closed. System operators may select datasets that will be saved and not purged. The LPGS can display storage statistics to verify that sufficient storage is available to accommodate the receipt of products that will be processed for that day.

The LPGS receives URFs from the ECS. The URF is the customer request for an L1 product. The URF contains a request identifier, which is used to track the individual product requested in a customer order. The URF information is forwarded to the processing control function for incorporation into the schedule. The LPGS creates a product request for each product URF. The product request contains information extracted from the original URF, including processing parameters, request identifier, and L0R data identifier. The product request is incorporated into the current processing queue as soon as it is complete.

The LPGS may also receive ECS operator requests for canceling a product generation request. In this case, the operator must manually perform the cancellation, causing termination of processing and closure of the product request. After closure of a canceled product request, the operator can review the production status to confirm reallocation of resources.

After generation of the product request is complete, information identifying the required L0R product extracted from the URF is used to create an order for an L0R product. That order is transmitted to the ECS. The LPGS then receives notification from the ECS that the L0R product is available for retrieval. The LPGS retrieves the product from the ECS disk space and notifies the ECS that the product has been successfully received. When the L0R product has been successfully received, production status is automatically updated to indicate that all required data are available and that processing may commence. Operators can review production status and system monitoring displays.

3.2.1.2 Production

As resources become available, image processing is initiated. L0R products, including the appended CPF or IC data, PCD, and MSCD, are accessed for processing.

During L1 product generation, statistics generated during selected characterizations are collected for periodic retrieval by the IAS. The LPGS also collects quality and assessment information that can be reviewed during postproduction analysis. Image quality is nominally verified automatically after processing has been completed. Postproduction analysis may include visual inspection of the digital image and generation of trouble tickets for transmission to the ECS if the image fails quality checks, as documented in operations procedures.

3.2.1.3 Postproduction

After completion of L1 image generation, metadata are created according to the desired format, and other product components are assembled. Final product formatting is performed, and the quality of the output product is verified. The L1 product is transferred to the output area in preparation for retrieval by the ECS. The LPGS notifies the ECS of the availability of the L1 product using the request identifier and established message protocol. After the ECS has retrieved the L1 product and notified the LPGS, the data are marked for purging from the staging area. The LPGS then closes the product request and updates the database.

Characterization results containing output from characterizations performed during radiometric processing are stored in the LPGS database and routinely retrieved by the IAS. Characterization results can include statistics obtained from characterizations for IC processing and banding. After the IAS retrieves trending data, the data are marked for deletion and periodically purged from the LPGS database.

On completion of the day's production schedule, operators set controls and production parameters for processing performed during work shifts in which staff is reduced and systems are less attended.

3.2.2 Data Quality Analysis and Anomaly Resolution

Data quality thresholds are set by operators before L1 image processing. The operators select, through the operator interface, processing options and quality thresholds based on desired corrections and error limits. Images can be generated and distributed without visual inspection as long as quality thresholds documented in operations procedures are not exceeded.

3.2.2.1 Anomalies Found During L1 Processing and Postproduction Analysis

When an image is found to not meet quality thresholds, or it fails visual inspection at a point in the process, anomaly analysts initially examine production quality results to determine if the source of the anomaly is within the LPGS image processing system. If reprocessing the image does not resolve the anomaly, options specified in the L1 product request and the processed L0R image are analyzed to identify a possible cause. A benchmark and/or diagnostic run may be processed by the LPGS analyst to verify if there are problems with LPGS image processing software. If no anomalies are found in the L1 product request, L0R image, or L1 production process, then a trouble ticket is entered into the ECS trouble ticket system.

3.2.2.2 Response to Customer Report of Anomalies

When customers report anomalies found in received L1 products to the EDC DAAC, the EDC DAAC element responsible for user services and production processing and distribution initially issues a trouble ticket, via the ECS trouble ticket system, if a customer has not already done so. A Problem Investigator is assigned according to the established Problem Resolution Process. Investigators determine whether the reported product anomaly occurred as a result of media generation and distribution of the L1 product to the customer. If the analysts determine that the source of the problem was not in the ECS distribution operation, but in the L1 product, the trouble ticket is assigned to the LPGS. The LPGS anomaly analysts examine the L1 product to verify that it was properly distributed to the ECS. The LPGS may then reprocess the image to determine whether the product is consistent with products received by the customer. If the reprocessed product is consistent with the anomalous product received by the customer, the LPGS anomaly analysts examine production quality reports to assess whether thresholds were approached. If no anomalies are found in the L1 product request, L0R image, or L1 production process, the available information is entered into the trouble ticket and resubmitted to the ECS trouble ticket system for additional analysis.

3.2.3 Algorithm Update

Modifications to the LPGS processing algorithms are coordinated through software maintenance and sustaining engineering operations. Nominally, algorithm updates identified by software developers or IAS analysts are proposed to the LPGS Project Configuration Management Board (PCMB), which includes representation from the LPGS and the IAS organizations. The algorithm is integrated into the test baseline and tested in a model of the image processing subsystem in the development, test, and maintenance environment. Processing tests include duplicating processing of sample images for comparison of results between the test and production environments, as well as the IAS, if possible. It is assumed that the IAS and the LPGS will maintain a common algorithm baseline. After the PCMB review and approval of the algorithm update, the updated algorithm is scheduled for integration into the production baseline. Modification of the production baseline is scheduled for offpeak hours and includes regression testing that duplicates sample image processing performed in the test environment.

3.2.4 Reprocessing

Reprocessing of L1 images can be performed to respond to analysis of data quality assessments, to support anomaly resolution, to support algorithm integration and system regression test processing of benchmark calibration or known good scenes, and to recover from failures that resulted in loss of production images. Any requests from the ECS for reprocessing L1 products are transmitted as new product requests to the LPGS; the LPGS has no knowledge that they are reprocessing requests. The position of the new product request within the processing queue can be modified to support expedited reprocessing.

3.2.5 Product Accounting

The Landsat 7 Mission Management Office (MMO) provides price information directly to the ECS, on a per-product basis, for Landsat 7 L1 ETM+ products at the start of the Landsat 7 mission. Pricing information updates are provided by the MMO, coordinating with the ECS, as needed. The interface for product price information distribution is described in the ICD between the ECS and the Landsat 7 System (Applicable Document 3).

Estimates of prices for products are provided on request to customers, as described in the ECS Operations Concept (Applicable Document 2).

3.2.6 Documentation and Production Software Distribution

At the start of the Landsat 7 mission, the LPGS provides documentation to the ECS that describes the processing that may be performed on products that can be requested by users. This documentation can include descriptions of algorithms that may be applied, as well as descriptions of coordinate reference systems, output formats, orientation, grid cell size, resampling, and spectral channels that can be selected for processing. The ECS in turn uses this documentation to create information maintained by the ECS to populate guide and directory documents, which facilitate customers' ordering L1 products, or distributed to customers through the ECS advertising service. The ECS is provided with updates to the documentation according to the LPGS Configuration Management Plan (Applicable Document 20). Production software is distributed to the ECS, which in turn can make the software available to customers through EDC's centralized documentation distribution and handling facilities.

3.2.7 System Test and Maintenance

The LPGS development, test, and maintenance functions provide an environment to support routine system maintenance and sustaining engineering. The functions provide redundancy for the image processing and can be used as a backup to support contingency operations. These functions are used in development of software updates and provide an environment, including regression test data, for acceptance testing software modifications without impact to operations. Benchmark images are maintained to support anomaly resolution and testing. This environment can be used to support end-to-end testing of Landsat 7 digital image product ordering and processing without impact to operations, from search and order through the ECS to distribution of L1 image products to the customer.

3.3 Contingency Operations

This section describes major operational activities performed by the LPGS in response to system anomalies and failures, both internal and external to the LPGS.

3.3.1 LPGS Failure

A failure of the LPGS can be caused by failure of any LPGS subsystem that provides operational support of L1 image production, with the exception of the development, test, and maintenance

functions. LPGS failure can be detected by analyzing error messages received during communication, data retrieval, scheduling, image processing, or image analysis. The LPGS operators notify the EDC DAAC management and user services and production support offices of the failure, either electronically or through a contingency medium or method. Operations procedures are implemented to isolate the failure within a specific LPGS subsystem. Operations procedures are followed to resolve and recover from the failure. As information becomes available, an estimate of the impact on production operations and of the time to return to full or partial operations may be provided. If the production planning functions are available, processing estimates may be made, and a tentative modification to the latest production status can be provided. After a failure is resolved, updated production status is provided. L0R products that have been lost or corrupted before processing are again requested from the ECS and processed according to the modified production status. L1 products that have been lost before distribution to the ECS are reprocessed and distributed.

3.3.2 Failure of Communication Links to the ECS

In the event of failure of communications links between the LPGS and the ECS, the DAAC manager and the ECS system operator are notified of the failure by voice communications. Operations procedures are followed to determine which communication link failed. The LPGS distribution and message transmission functions are configured to discontinue notification of availability of L1 products and L0R acquire requests to the ECS. The LPGS production schedule continues to be followed, as much as possible, with continued processing of L0R products that are on LPGS disk space. If production can no longer continue because all online L0R products have been processed, then alternative methods can be used, if available, to request and retrieve L0R products. L1 products that have been produced are held on LPGS disk space until communications have been reestablished and verified.

Abbreviations and Acronyms

CCR	configuration change request
CPF	calibration parameter file
DAAC	Distributed Active Archive Center
DSS	data server subsystem
ECS	EOSDIS Core System
EDC	EROS Data Center
EGS	EOS Ground System
EOS	Earth Observing System
EOSDIS	EOS Data and Information System
EROS	Earth Resources Observation System
ESDIS	Earth Science Data and Information System
ETM+	Enhanced Thematic Mapper Plus
FIFO	first in, first out
GB	gigabyte
GeoTIFF	Georeferenced Tagged Image File Format
GSFC	Goddard Space Flight Center
GW	gateway
HDF	hierarchical data format
IAS	Image Assessment System
IC	internal calibrator
ICD	interface control document
IGS	international ground station
INS	ingest subsystem
L0R	Level 0 reformatted data
L1	Level 1
L1G	Level 1 geometrically corrected
L1R	Level 1 radiometrically corrected

Landsat	Land Satellite
LGN	Landsat ground network
LGS	Landsat 7 ground station
LPGS	Level 1 Product Generation System
LPS	Landsat Processing System
MB	megabyte
MMO	Mission Management Office
MOC	Mission Operations Center
MSCD	mirror scan correction data
NASA	National Aeronautics and Space Administration
PCD	payload correction data
PCMB	Project Configuration Management Board
PLS	Planning Subsystem
SDPS	science data processing segment
SDR	system design review
SRR	system requirements review
SSR	solid state recorder
URF	user request file
WRS	Worldwide Reference System